Tonal development of normally developing children aged 12-24 months

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Abstract

This study aimed to evaluate the previous research findings on tonal development, specifically in terms of high vs. low tones, level vs. contour tones, and rising vs. falling tones. Fourteen Cantonese-speaking participants with normal development in age groups of 12, 15, 18, 21, 24 months were followed in a cross-sectional study for 3 months, while 5 were followed longitudinally for 3 months with 4 visits. Spontaneous speech was elicited naturally and 10-minute recording was extracted. The acquisition criterion used was 5% of occurrence in the speech extract. This study showed consistency with previous studies in terms of development: 1) high tones preceded low tones; 2) level tones preceded contour tones; 3) the duration of tone acquisition took less than 12 months. But it was interesting to find that Low Falling tone (T21) was acquired at a later stage when compared with previous researches. Possible explanations were discussed and further investigation was suggested.

Introduction

A tone language is ‘one in which an indication of pitch enters into the lexical realization of at least some morphemes’ (Yip, 2002). Cantonese is one of the world’s tone languages in which the lexical meaning of a word changes when tone varies. There are basically six different tones in Cantonese (Bauer & Benedict, 1997), though there may have different tone categorizations according to different systems.

“A tone contour has both a vertical dimension of pitch height and a horizontal dimension of direction of pitch movement” (Bauer & Benedict, 1997). Tone contour is the movement in the pitch from the beginning of the tone to its endpoint. The tone contours of Cantonese can be characterized by three pitch registers (high, mid, low) and three directions of pitch movement (level, rising and falling). Examples of the three types of tone contours were shown in Figure 1 below. According to Bauer & Benedict (1997), a high level tone starts at high and remains high throughout the production and has a tone contour of 55. A low rising tone rises from mid-low to mid and has a tone contour of 23; and a low falling tone falls from mid-low to low and has a tone contour of 21.

The six contrastive tones were usually described with a numerical sequence: Tone 1 High Level (T55/T53); Tone 2 High Rising (T35/T24); Tone 3 Mid Level (T33); Tone 4 Low Falling (T21/T11); Tone 5 Low Rising (T23); and Tone 6 Low Level (T22).

Entering tones appear for lexicons ending with consonants /-p/, /-t/, /-k/. The numerical tone value of the three entering tones corresponds to the three pitch registers, i.e. High Entering (T5), Mid Entering (T3), and Low Entering (T2). These three entering tones are treated as allotones of the High Level, Mid Level and Low Level tones respectively as they have the similar height but differ only in length (So, 1996).

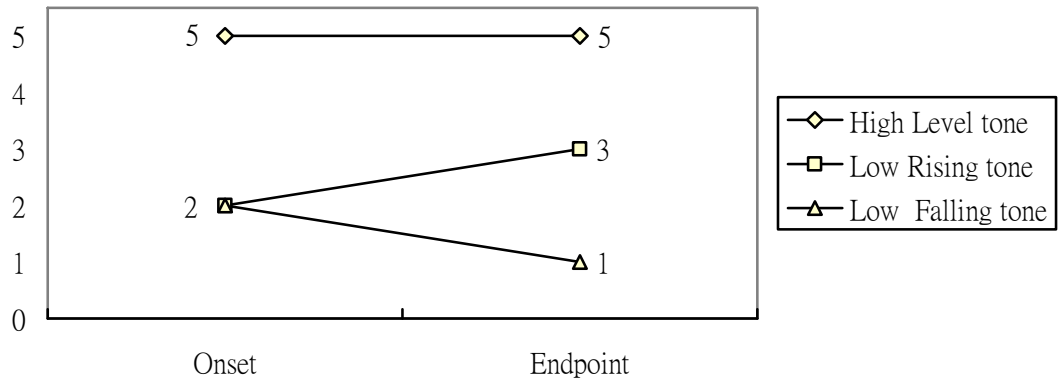

Figure 1: Tone contours of high level (55), low rising (23), and low falling (21) tones

The tone letter devised by Chao (1947) includes a vertical lone as the baseline of the tone letter and a horizontal line attached to it symbolizing the direction of movement of the tone contour, for example, High Level "˥", High Rising "˧", and Low Falling "˩". In this paper, numerical tone values of their starting and ending points from 1 to 5 will be used. The classification of tone varies according to different scholars (see Table 1 below); their tone categories of the six contrastive tones remain the same, with the same pattern of tone contour but differs in the numerical values of pitch height.

In this study, the most updated tone classification derived by Zee (1991) was adopted, except for the High Rising tone. The High Rising tone is generally assigned with the tone value of 35 by other researchers. Thus, this tone value of 35 was used in this study rather than the tone value of 24 suggested by Zee (1991). Specifically, the tone value of the six contrastive tones used in this study were tone 55 (High Level), tone 35 (High Rising), tone 33 (Mid Level), tone 21 (Low Falling), tone 23 (Low Rising), and tone 22 (Low Level).

Table 1: The classification of Cantonese tones

		Tone value			
	Tone category	**Chao (1947)**	**Hashimoto (1972)**	**Vance (1976)**	**Zee (1991)**
Tone 1	High level/ high falling	55/53	53	55	55
Tone 2	High rising	35	35	35	24
Tone 3	Mid level	33	44	33	33
Tone 4	Low falling	21	21	11 (low level)	21
Tone 5	Low rising	23	24	13	23
Tone 6	Low level	22	33	22 (mid-low level)	22

Chinese tone language: Mandarin and Cantonese

Researches on tonal acquisition in Mandarin and Cantonese had been carried out since 1970s using single case study or longitudinal study. The expression in spontaneous speech during natural interaction was usually being measured. Other researches investigated tonal perception instead of tonal production. The results obtained in previous studies had both similarities and disagreements and it was summarized in Lee (1996).

Mandarin

Li and Thompson (1977) carried out a cross-sectional and longitudinal study on tonal production acquisition in Mandarin. In their study, data were collected from seventeen children

aged 18 – 34 months of Mandarin-speaking families in Taipei, by eliciting naming responses to pictures, while ten of these children were followed over a period of seven months. There were a number of findings in stages of tone acquisition. However, no specific information about the individual child's age was given. Though this study did not give comprehensive data on tone acquisition, it provided a framework for further studies on this area. Tones were found to be acquired more rapidly than segmentals. It was found that high level tone was acquired first, followed by high falling tone, and finally high rising and dipping tones. Similar findings were mentioned by Clumeck (1980), which rising and low dipping tones in Mandarin were much difficult to recognize as confusion between these two tones occurred at an earlier age.

Cantonese

There were relatively few studies working on the tonal acquisition in Cantonese.

Similar acquisition pattern in terms of tonal contours was found in the researches in Cantonese. J. K.P. Tse (1978) carried out a longitudinal study on tonal acquisition. Data were collected from J. Tse's son for 32 months since he was born. J. Tse's study supported the findings of Li and Thompson, that "change of tone was more detrimental to comprehension than change of segmental pattern". In Li and Thompson's study, spontaneous production of the word [caŋ jiŋ lu] (representing "giraffe") was found to obtain its tonal accuracy at an earlier age but became more phonological accurate later, whereas the response mode to the word /tɛŋ/ (representing "lamp/light") with different tones was experimented in J. Tse's study. Concerning the acquisition of tone, the observed acquisition pattern was that level tones were acquired earlier than contour tones, and that falling tones preceded the rising tones in Cantonese. It was noted that the mastery of tonal production was as early as age two, which was parallel to the findings

from So & Dodd (1995), in which the duration for his son to produce all six contrastive tones was approximately 9 months.

Another longitudinal single case study of aged 14 – 30 months done by A. C. Y. Tse (1991) reported that high level tone was acquired the earliest. There was disagreement between the two studies in Cantonese, in which the Low Level tone (T22) was an early tone and Low Falling tone (T21) was not acquired yet by age 2;0. Though the mastery of tonal production was not as early as two, the duration required for acquiring the six tones were about 10 months. It was also reported that tonal acquisition was found to be completed before segmental acquisition.

The pattern of tonal acquisition reported from J. Tse and A. Tse studies were as in Table 2. It was noted that J. Tse's study used the tone classification of Vance, and the tone value below was modified using Zee's classification.

The discrepancies between research findings on tonal acquisition in Mandarin and Cantonese would possibly be due to the different criteria used for determining acquisition. Most studies based their acquisition criteria on phonetic accuracy in tonal articulation, whereas some based on the consistency required for establishing mastery. However, the criteria for tone acquisition were not specified in the studies, that is, the number of occurrence to be counted as phonetically accurate or consistent was not included.

Previous studies did not specify the method in eliciting the subject's spontaneous speech in the data collection process explicitly. Besides, there were no recordings in between the data collection intervals. Recording between each visit can increase the validity of the study, as the participants' spontaneous speech obtained may not be the actual performance when compared with the absence of strangers. Another reason is to obtain a more detailed observation in the acquisition pattern in case of there may have great discrepancies occurred between the data

collected between two consecutive visits.

Foreign tone languages

There are a variety of tone languages around the world, and there had been researches on tone languages in different areas, for example, Sesotho language (Demuth, 1995). The tone classification and the assigned tone values for different languages were different depending on the number of pitch registers of that particular language. There were some universal trend in the tonal acquisition across different language, however, the acquisitions was language-specific (Yip, 2002).

Aim of the study

This study aimed to evaluate the research findings of the previous studies with a larger group of subjects, which the expressive ability will be focused. Specific research questions were 1) to obtain a general picture of the order of tone development; 2) to investigate the observed pattern in tone development, including high tones vs. low tones; level tones vs. contour tones, rising tone vs. falling tones; and 3) to evaluate the duration for acquiring all six contrastive tones.

It was hypothesized that the acquisition pattern of this study will be similar to the one of A. Tse. The reason was that the acquisition criteria were selected to be the consistency required for establishing mastery of tone. The findings were to find out the general developmental pattern on tonal production, which provide further information on tonal development of normally developing Cantonese children.

Table 2: Comparison of the pattern of tone acquisition in studies of J. Tse and A.Tse

Age (months)	J. K.P. Tse (1978)*	A. C.Y. Tse (1991)#
14		
15	T55	
	T21	
16		
17	T33	T55
18	T35	
	T5	
19	T3	T33
	T2	T35
20		
	T23	
21	T22	
22		
23		T22
30		T5
31		
33		T21
34		
		T13
<36		T3
		T2

* In J. Tse's study, the criterion used refers to the tonal accuracy

In A. Tse's study, the criterion used refers to the tonal consistency

Methodology

Participants

Fourteen participants (8 males and 6 females) were selected, ranged from 12 to 25 months (mean age: 16 months) at the first date of data collection. Their background information of the participants was summarized in Table 3 below. They were recruited through personal contacts of the author of this paper and the friends of the participants' parents. The fourteen participants were divided into five groups according to their age (12 month, 15 month, 18 month, 21 month and 24 month). They were followed in a three-month cross-sectional study, while one participant in each group was followed longitudinally.

The participants who are included in the study fulfilled at least four prerequisites. These include 1) the participants' parents are Cantonese-speaking and use Cantonese as the main language in daily communications with the participants; 2) they have no structural, physiological and/or neurological deficits; 3) they have no cognitive or behavioral problems; and 4) they have no hearing problem.

Originally, there were 20 participates in this study, but six of them were excluded in the study after the first time of data collection. The reason was that one participant was a premature baby, one was in hospital in the fourth time of data collection, and the remaining four withdrew from the study due to the unavailability of the parents for the second data collection visit.

Table 3: Background of the participants

Age group (month)		Name	Gender	DOB	Age* (month)	Main Caregiver	Language Used at Home	Estimated time per week # (hours)	Home Servant (Language used)	No. of siblings
12	1	SSY	M	14/11/2002	12	mother	Cantonese , Fukienese	70	Cantonese	1
	2	TCH	M	11/10/2002	12	mother	Cantonese	84	no	3
	3	YPK	M	8/9/2002	13	Maid	Cantonese	35	Cantonese	0
15	4	CKK	F	6/9/2002	14	grandma	Cantonese	39	no	0
	5	LTC	F	3/8/2002	15	Maid	Cantonese , English	39	Pilipino	0
	6	YMY	F	29/6/2002	16	grandma	Cantonese	39	no	0

18	7	LYW	M	4/4/2002	18	maid	Cantonese , English	39	Pilipino	0
	8	TCJ	M	15/4/2002	18	maid	Cantonese	39	Cantonese	0
21	9	TKC	F	17/1/2002	21	mother	Cantonese , English	84	no	0
	10	LPH	M	2/2/2002	21	Mother	Cantonese, Mandarin	39	Indonesian	0
	11	MWH	M	13/1/2002	22	mother	Cantonese	84	no	0
24	12	CYK	F	3/10/2001	25	mother	Cantonese	39	no	0
	13	TCW	M	6/10/2001	25	mother	Cantonese	70	no	2
	14	LPM	F	1/9/2001	25	maid	Cantonese	39	Cantonese	2

* Age: the age in months at the first date of data collection

Estimated time used in playing with the participants

Procedure

All parents were asked to sign the consent form (see Appendix A). Case history of each participant in the form of an interview with the parents was conducted prior to the recordings at the first date of data collection (Appendix B). The questions included the personal particulars of the participants, their medical history and developmental milestone, the parents' particulars and the language used at home while playing with the participants. All participants were brought up in a Cantonese-speaking family, while SSY's mother speaks both Cantonese and Fukienese at home. The education level of the participants' parents was all secondary five or above. Ten of them were the single child in the family while the remaining ones had siblings ranged from one to three in number. Seven of the families had home servants taking care of the children, in which four speak in Cantonese, while three speaks in English with simple Cantonese. As reported from the interview, the average estimated time spent playing with the children each week is approximately 60.5 hours, ranged from 35 hours to 84 hours.

The five groups of participants were followed in a cross-sectional study, which two visits were conducted within a three-month interval. The age of the participants in each group was three-month apart, which formed a pseudo-longitudinal study over a year. This aimed to obtain a general picture of the tone development from aged 12 months to 27 months. Moreover, one participant in each group was then followed longitudinally, in which four visits at a three-week interval were conducted. This was done in order to obtain a continuing profile of tone acquisition and to observe if there was any specific patterns in-between the three-month time gap.

Equipment

The equipment for data collection included a digital voice recorder (SAMSUNG VH 350) with an external microphone. The process of data collection was done within the period of November 2003 to January 2004, with audio-recording during natural interactions with their parents, relatives or the author, for about an hour. The parents will be encouraged to interact with their children as usual, and the author would also play with the participant. The materials for playing with the participants were all taken from their home, which were familiar to the participants.

Reliability measure

Both intra- and inter-reliability were measured. For intra-reliability, 10% of the speech sample was re-transcribed one month after the first completed transcription, while another 10 % of the speech sample was transcribed by two native Cantonese-speaking individuals with knowledge in phonetics to check inter-rater reliability. The two raters came to an agreement that any disagreements or questionable productions will be excluded in the transcription.

The percentage of occurrence for the tones was calculated and had met the criteria of at least 70% of agreement among the author and the two transcribers in order to be classified as valid (see Appendix C for details).

Data analysis

Data selection

For each one-hour recording, 10-minute conversation was extracted from the recorded materials. The 10-minute extract was selected by the author perceptually, in which the period when the participants most actively participated was captured.

The transcription of the 10-minute recordings captured was done on the recording sheet (Appendix D). The productions made by the participants in the captured duration were all transcribed using the Cantonese International Phonetic Alphabets (Zee, 1991). These include vocalizations, word-like vocalizations, and recognizable words. For the word-like vocalizations and recognizable words, numerical tone value will also be included after the phonetic symbols.

Data analysis procedure

In order to show the acquisition pattern of each lexical tone, the percentage of occurrence of each tone was calculated.

In the calculation, all meaningless vocalizations, productions in English and questionable productions, which cannot be recognized as a word, were excluded. Repetition of words was included, provided that the repeated words were not echoed meaninglessly in the captured duration. Therefore, the percentage of occurrence of each tone was the dividend of the number of token of that tone from the total number of recognizable syllables transcribed. The acquisition criterion was set to be 5% of occurrence in the conversation. The framework of determining the acquired tones using consistency was adopted from the study of A. Tse (1991). However, the acquisition

criterion of consistency was not explained quantitatively. For eliminating the possibility in producing certain tones at change level and to avoid the errors made in the transcription, 5% of occurrence was used in this study.

The results were then tabulated with respect to each lexical tone and analyzed descriptively in terms of the pattern of occurrence.

Results

There were a few major findings from the results obtained. (Table 4)

1) The order of tone development in general:

$$T55 > \begin{matrix} T33 \\ T35 \end{matrix} > \begin{matrix} T21 \\ T23 \end{matrix} > T22$$

2) The pattern of tone acquisition

   i. high level tone was acquired at an earlier stage, while low level tone was acquired at a later stage

   ii. high tones preceded low tones

   iii. level tones preceded contour tones

   iv. rising tone preceded falling tones

3) The duration of tone acquisition is approximately 10 months

Table 4: The order of tone acquisition in this study

Tone register	12 months	15 months	18 months	21 months	24 months
High	T55	T5			
Mid		T35 T33	T3	T23	
Low				T2 T21	T22

Cross-sectional Study

Tone acquisition patterns observed in cross-sectional study among the fourteen participants were shown in Table 5 (see Appendix E for details).

Earliest and latest tones acquired

High Level tone 55 was acquired at the earliest stage, in which all of the participants acquired as early as the age of 15 months, with the earliest age of 12 month (TCH). The productions were mainly in form of CV syllable structures, for example, [ma55-ma55] (representing “mother”), [pɔ55-pɔ55] (representing “ball”).

The production of High Level tone 55 was dominant in one of the participants’ (TCH) productions, which was as high as 49% of the 10-minute conversation analyzed. As for others, the percentage of occurrence of the High Level tone 55 yielded a relatively constant percentage in age group of the 12 months, ranged from 16% to 25%, among the productions made in the 10-minute conversation.

Table 5: Tone acquisition patterns observed in cross-sectional study

Age (month)	Name	Visit	T55	T5	T33	T3	T35	T21	T23	T22	T2
12	SSY	Visit 1									
	TCH	Visit 1	+								
	YPK	Visit 1									
15	SSY	Visit 4	+		+						
	TCH	Visit 4	+		+			+			
	YPK	Visit 4	+				+				
	CKK	Visit 1	+		+						
	LTC	Visit 1	+		+						
	YMY	Visit 1	+								
18	CKK	Visit 4	+		+		+				
	LTC	Visit 4	+	+	+	+		+			
	YMY	Visit 4	+		+		+				
	LYW	Visit 1				+					
	TCJ	Visit 1	+		+		+	+			
21	LYW	Visit 4	+		+						
	TCJ	Visit 4	+	+	+	+	+				+
	LPH	Visit 1	+	+	+		+	+	+		
	TKC	Visit 1	+		+	+	+	+	+		
	MWH	Visit 1	+		+		+	+			
24	LPH	Visit 4	+		+		+	+		+	
	TKC	Visit 4	+	+	+		+	+	+		
	MWH	Visit 4	+		+		+	+			+
	CYK	Visit 1	+		+		+	+	+	+	
	TCW	Visit 1	+		+	+	+	+	+	+	+
	LPM	Visit 1	+	+	+		+	+		+	
27	CYK	Visit 4	+	+	+		+	+	+	+	+
	YCW	Visit 4	+		+	+	+	+	+	+	-
	LPM	Visit 4	+	+	+	+	+	+	+	+	+

** “+” represents the percentage of occurrence > 5%

Low Level tone (T22) was acquired at the latest stage among the tones. The percentage of occurrence remained zero until the age of 24 months. The production of this Low Level tone (T22) first appeared to the participants LPH and TKC at the age of 21 months. Once this tone first appeared in the participants' production, it appeared in the subsequent recordings of the data collected.

High tones preceded low tones. This phenomenon applied to both level and contour tones. For level tones, High Level tone (T55) was noted at aged 13 months, Mid level tone (T33) at aged 15 months, and Low Level tone (T22) at aged 24 months. For contour tones, High Rising tone (T35) was noted at aged 15 months while Low Rising tone (T23) and Low Falling tone (T21) at aged 21 months. The high-low sequence remained for the entering tones as well, which High Entering (T5) at aged 15 months, Mid Entering (T3) at aged 18 months and Low Entering (T2) at aged 21 months.

Level tones preceded contour tones. High level tone (T55) emerged at an earlier stage than High Rising tone (T35), Mid-level tone (T33) before Low Rising tone (T23). Low level tone (T22) was the exception of this trend that contour tones, including Low Rising tone (T23) and Low Falling tone (T21), was acquired at aged 21 months, 3 months earlier than that of Low Level tone (T22). Despite of describing in general, across the same registers (high-mid-low), level tone emerged at an earlier stage than contour tone.

Rising tone preceded Falling tone. High Rising tone (T35) emerged as early as the aged of 15 months, while Low Falling tone (T21) emerged at the age of 21 months. While excluding the factor of high-low register of tone, Low Rising tone (T23) and Low Falling tone (T21) emerged almost at the same period of age 21 months. It was found that two of the participants, namely TCH, TCJ produced Low Falling tone (T21) as early as

the age 15 and 18 months respectively, but it should be noted that all of the tone (T21) was produced as a whole word representing the kinship terms, for example, [ma21-ma55] (representing “mother”), [tɛ21-tɛ55] (representing “sister”).

Tones were acquired early and the duration of the process of acquisition was approximately 10 months. The 12-month group participants uttered their first words with the correct High Level tone (T55) at the age of 12-13 months. One of the participants in the 21-month group was able to acquire the complete six-tone system at the age of 22 month, and the rest of the participants in the 21-month and 24-month groups showed all six contrastive tones in their productions by age 24 months.

Longitudinal study

The tonal acquisition pattern from the five participants followed longitudinally showed similar pattern when compared with the one obtained in cross-sectional study (see Table 6 below, and see Appendix E for details). In particular, high tone precedes low tone, level tone precedes contour tones, and rising tone precedes falling tone.

Individual changes on the tonal acquisition were observed. The first acquired tone was High Level tone (T55) at aged 14 months, Mid Level tones (T33) followed at aged 17 months. Contour tones were then observed, in which High Rising tone (T35) at aged 17 months, Low Falling tone (T21) and Low Rising tone (T23) at aged 21 months. It was noted that Low Falling tone (T21) was first noted at aged 15 months in the participants speech, produced as a word as the form of T21-T55, for example [ma21-ma55] (representing “mother”), addressing the kinship items. Low Level tone (T22) was acquired the latest, by which this tone was first observed at aged 24 months.

Discussion

This study aimed to evaluate the research findings of the previous studies with a larger group of subjects, by which the expressive ability was focused. The research question was to investigate the order of tonal development, namely high level tone vs. low level tone, level tones vs. contour tones; and rising tones vs. falling tone. The comparison in research design and methodology between previous researches on tone acquisition and this study was shown in Table 7.

Table 7: Comparison between previous researches on tone acquisition and this study

	Li and Thompson	**J. Tse**	**A. Tse**	**This study**
Research Design	Cross-sectional and longitudinal	Longitudinal	Longitudinal	Cross-sectional and longitudinal
No. of subjects	17	1	1	14
Method of elicitation	Spontaneous speech (picture naming task)	Spontaneous speech	Spontaneous speech	Spontaneous speech
Duration of data collection	7 months	32 months	22 months	3 months
Acquisition criterion	Tonal accuracy	Tonal accuracy	Tonal Consistency	5 % of occurrence in conversation

The order of tonal development

The results in this study can be presented in different aspects, in terms of level tones vs. contour tones; high level tone vs. low level tone, rising tones vs. falling tone; and high rising tone vs. low rising tone. In general, this study confirmed the general findings of the previous researches, except for the rising and falling tone acquisition.

Level tones vs. contour tones

The results indicated that level tones were acquired earlier than contour tone. The result was consistent to the findings in Li & Thompson, J. Tse, and A. Tse. Ohala's suggestion (1978) of rising tone is more difficult to acquire than level tone cannot help in differentiating a possible hypothesis suggesting level tones are easier to produce than contour tone. The reason was that there was no falling tone using Vance's tonal classification system, which the Low Level tone (T11) corresponds to Low Falling tone (T21) using Zee's system.

A possible explanation of this observation was that there might have a need to have a change in the pitch register when producing contour tones, but not level tones. It was also suggested in Zhu (2002) accounting for the tonal acquisition pattern in Mandarin, that level tones only consist of one unit of default specification, while contour tones are a linear sequence of two or several different level tones. For example, the onset and the endpoint remained at the same pitch register for level tones, whereas the onset and the endpoint of the pitch register were different for contour tones.

Table 6: Tone acquisition patterns observed in longitudinal study

	Age (month)	**Visit**	**T55**	**T5**	**T33**	**T3**	**T35**	**T21**	**T23**	**T22**	**T2**
YPK	**12**	Visit 1									
	13	Visit 2									
	14	Visit 3	+								
	15	Visit 4	+				+				
YMY	**15**	Visit 1	+								
	15	Visit 2	+	+							
	16	Visit 3	+		+	+					
	17	Visit 4	+		+	+	+				
TCJ	**18**	Visit 1	+		+	-	+	+			
	19	Visit 2	+		+	+	+	+			
	20	Visit 3	+		+		+				
	20	Visit 4	+	+	+	+	+				+
TKC	**21**	Visit 1	+		+	+	+	+	+		
	22	Visit 2	+		+		+	+			
	23	Visit 3	+	+	+		+	+	+		
	24	Visit 4	+	+	+	+	+	+	+		
LPM	**25**	Visit 1	+	+	+		+	+		+	
	25	Visit 2	+	+	+	+	+	+	+	+	
	26	Visit 3	+	+	+	+	+	+	+	+	+
	27	Visit 4	+	+	+	+	+	+	+	+	+

* “+” represents the percentage of occurrence > 5%

High Level tone (T55)	5 → 5
Pitch register	high → high

High Rising tone (T35)	3 → 5
Pitch register	mid → high

The shift in pitch register for contour tones, but not for level tones, could also be applied to Cantonese, and be taken into account for the observed pattern of level tones preceded contour tones.

High tones vs. low tones

Level tones: The results indicated that High Level tone (T55) was acquired at an early stage, the earliest acquired age was found at age 12 months in TCH as the production was already in the repertoire in the first visit of data collection. These were all consistent with the findings of J. Tse and A. Tse. Mid Level tone (T33) then followed, which was acquired at age of 15 months. Then, Low Level tone (T22) was acquired at the later stage that it first appeared at age 21 months in LPH's and TKC's productions and eventually appeared in the repertoire of other participants' production by age 24 months. Being the allotones of the level tones, the order of the three entering tones agreed with this trend, which High Entering (T5) was acquired first, followed by Mid Entering (T3) and then Low Entering (T2).

Contour tones: In this study, High Rising tone (T35) was acquired at age 15 months, whereas Low Rising tone (T21) was acquired at the age of 18 month. The three months

lag was consistent with the previous findings, but the age of acquisition was approximately 2 months earlier than J. Tse's findings.

The sequence of acquiring level tone from high, mid, and finally low could be explained by the perception of tonal contrast. The study of Ching (1984) indicated that there is tonal confusion of mid level and low level tones as well as low rising and low level tone until they were able to recognize isolated lexical tones at about four years of age. This could be a possible explanation for the findings that low level tone was acquired at the latest stage among all lexical tones.

Rising tones vs. falling tone

In this study, rising tones was acquired at an earlier stage than falling tone, in which High Rising tone (T35) was mastered at age 15 month, Low Rising tone (T23) and Low Falling tone (T21) were acquired at age 21 month. When eliminating the factor of the pitch register, that is comparing Low Rising and Low Falling tones only, it was found that the age of acquisition for the two low contour tones was approximately the same. This contradicts the findings of J, Tse, Li and Thompson that falling tone preceded rising tones.

The Low Falling tone (T21) first appeared in two of the participants' (TCH and TCJ) productions at the age of 15 and 18 months respectively, at the forth visit for TCH and second and third visits for TCJ. It was interesting to note that all of the low falling tones produced at early stage were items addressing kinship terms, produced together with a high level tone, for example [ma21-ma55] (representing "mother"). At the age of 21 months, other items with Low Falling tone (T21) appeared. This implied that the

participants at an earlier age was able to produce Low Falling tone (T21) only for particular lexical items of addressing kinship, but they were still not able to produce the Low Falling tone at a lexical level until age 21 months.

According to Ohala (1978), falling contours involve a greater pitch range than a rising contour in order to be perceived with a prominent level. This did not tell whether falling tones were more difficult to produce, yet gave the idea that perception of tonal contrast by other individuals would also be a factor. The reasons for the pattern that Low Falling tone (T21) was acquired at a later stage when compared with the previous findings were still unknown. However, there might have two possible reasons. First, the vocabulary knowledge of the participants was not obtained. Light, T. (1977) suggested that small vocabulary presented few minimal pitch contrasts. This implied that with the larger the vocabulary size, there might have more different tones produced. Another possibility was that the linguistic input from the parents or family might vary, which the mother-child interaction might have direct influence on the development of the participants. These two possible factors can be resolved by employing a comprehension for controlling the confounding variable of vocabulary knowledge (Lee, Chiu, and Hasselt, 2002) prior to the study, and to analyze the distribution of different tone produced by the parents in daily conversation. These could be further investigated in future studies.

Conclusion

This study provided a more detailed description in the method in elicitation and data analysis procedures for a larger group of participants. In this study, High Level tone (T55) was acquired the earliest, at about 12 month, High Rising (T35) and Mid Level (T33) tones then appeared at 15 months of age, Low Rising (T23) and Low Falling (T21) tones appeared at about aged 21 month, whereas Low Level tone (T22) was acquired at the latest age, 24 months.

The result obtained was generally consistent with the previous research findings, whilst Low Falling tone (21) was found to be acquired at a later stage when compared with the findings of Li and Thompson and J. Tse.

The limitations of this study included the following: 1) The gender distribution of the participants was not even, in which the 15-month group was all females, and the 12-month and 18-month groups were all males. 2) The time interval being studied might not be long enough to capture the data in a continuum, due to great individual variations among participants. 3) None of the parents did the recordings between each time of data collection as suggested in the first visit. 4) The 10-minute conversation selected for transcription was done perceptually, which certain tones which supposed to be acquired earlier might not appear in the 10-mintues extract.

In response to the limitations mentioned, certain modifications could be made. 1) The gender distribution would be better controlled while selecting participants, though the gender factor may or may not contribute to the stages in tonal acquisition. 2) The duration of data collection period could be lengthened to allow a greater overlapping in terms of age and to capture a comprehension set of data. 3) Home recording in-between

each time of data collection was recommended, which served as a reference to see if there were any great discrepancies in the two sets of consecutive data collected. 4) The extracted conversation from different contexts was suggested, rather than the most actively participated conversation, so as to increase the likelihood in capturing different lexical tones.

In view of the direction of further researches on tonal acquisition, a comprehension screening test in exploring the vocabulary repertoire was recommended help in controlling another variable factor which would affect the tone development. The tonal acquisition on perceptual or instrumental methods could also be investigated to confirm the findings in the previous studies.

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Appendix A: Consent form

幼兒聲調發展研究

本人乃香港大學教育學院言語及聽覺科學部四年級的學生，現進行一項有關一歲至兩歲半兒童聲調發展的研究，作爲本人學士學位的畢業論文。研究對象是廣州話作爲母語的幼兒，年齡介乎一歲至兩歲之間。希望能夠得到你們的幫助，使研究得以順利進行。

資料搜集會以家訪形式進行。從二零零三年十一月至二零零四年一月期間，本人會每隔三星期進行一次約兩小時的家訪，並以錄音或錄影方式拍攝及記錄兒童在日常生活中發出的聲調。

研究過程中所獲得的資料會絕對保密，而錄音或錄影的記錄亦不會有幼兒的姓名記錄在內。

如閣下願意幫忙或有任何查詢，請與本人聯絡 (電話: 60918141; 電郵: h0004852@hkusua.hku.hk)。

同意書

幼兒姓名: _____ 性別: 男 / 女

出生日期: _____/_____/_____ 父或母姓名: _____

幼兒聲調發展研究

本人(父或母姓名)_____同意本人子女_____參與香港大學教育學院言語及聽覺科學部四年級學生方嘉文畢業論文的研究項目，並同意以錄音及錄影方式記錄研究過程。本人明白研究記錄不會顯示本人子女的姓名，而所獲得的資料亦只作研究之用，並會絕對保密。

上述所有事項，學生方嘉文已向本人詳細解釋，本人亦完全明白其內容。

_____	_____	_____
家長簽署	梁長城博士 論文指導導師	方嘉文小姐 四年級學生
_____	_____	_____
日期	日期	日期

Appendix B: Case History form

Child's background

Name: Eng:_____ (Chi:_____) nickname:
Date of birth: _____/ _____/ _____ Gender: M / F
Full term: Y/ N Nature of labor: eventful/ uneventful
Birth weight: Complication at birth:

Developmental milestones:

a) taking step s at mth
b) babbling at mth
c) one word stage at mth

Testing received:

a) hearing test: Time Venue
b) IQ test: Time Venue
c) Language test: Time Venue
others:

Primary care-taker:

Grandparents: Y/N Language: Cantonese/ dialect _____
Maid: Y/ N Pilipino/ Indonesian/ Chinese language: _____
No of siblings: 1) _____ DOB _____ M/F
2) _____ DOB _____ M/F
3) _____ DOB _____ M/F
** quantity and quality of interaction _____

Parents' background

	Mother	**Father**
Name		
Contact		
Age		
Education		
Occupation		
Language use		
Dialect		
Time spent with child	Hours per week	Hours per week
Language	Cantonese/ English	Cantonese/ English

** Grandparents:
** Cantonese-speaking peers:

Appendix C: Reliability measures

	Intra-rater reliability	Inter-rater reliability	
Tone value		**Transcriber 1**	**Transcriber 2**
T55	1.01	0.82	0.83
T35	0.96	0.62	0.64
T33	0.90	0.93	0.66
T21	1.06	0.61	0.79
T23	0.92	0.64	0.92
T22	0.98	1.18	0.73
Average	0.97	0.80	0.76

Appendix D: Record sheet for transcription

Subject name: _____ Transcriber name: _____

Transcription duration: _____

Page number: _____

	Time	Production	word representing
1			
2			
3			
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35			

	Time	Production	word representing
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37			
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Appendix E: Percentages of occurrence of each tone of the participants

Cross-sectional study

Age (months)	Name	Visit	T55	T5	T33	T3	T35	T21	T23	T22	T2
12	**SSY**	Visit 1	0%	0%	0%	0%	0%	0%	0%	0%	0%
	TCH	Visit 1	8%	0%	0%	0%	0%	0%	0%	0%	0%
	YPK	Visit 1	0%	0%	0%	0%	0%	0%	0%	0%	0%
15	**SSY**	Visit 4	25%	0%	5%	0%	2%	0%	0%	0%	0%
	TCH	Visit 4	49%	0%	8%	0%	2%	10%	0%	0%	0%
	YPK	Visit 4	16%	0%	0%	0%	12%	0%	0%	0%	0%
	CKK	Visit 1	39%	0%	10%	0%	0%	0%	0%	0%	0%
	LTC	Visit 1	55%	0%	15%	0%	3%	0%	0%	0%	0%
	YMY	Visit 1	5%	0%	3%	0%	3%	0%	0%	0%	0%
18	**CKK**	Visit 4	13%	0%	37%	0%	10%	0%	0%	0%	0%
	LTC	Visit 4	38%	5%	20%	18%	0%	5%	0%	0%	0%
	YMY	Visit 4	26%	0%	15%	0%	18%	1%	0%	0%	0%
	LYW	Visit 1	0%	0%	0%	6%	0%	0%	0%	0%	0%
	TCJ	Visit 1	25%	2%	27%	2%	9%	9%	0%	0%	0%
21	**LYW**	Visit 4	31%	0%	38%	0%	0%	0%	0%	0%	0%
	TCJ	Visit 4	13%	8%	25%	11%	19%	0%	0%	0%	5%
	LPH	Visit 1	15%	19%	34%	1%	9%	6%	5%	1%	0%
	TKC	Visit 1	22%	2%	17%	5%	14%	13%	11%	1%	0%
	MWH	Visit 1	28%	13%	14%	5%	13%	20%	5%	2%	0%
24	**LPH**	Visit 4	22%	1%	23%	0%	10%	9%	4%	6%	1%
	TKC	Visit 4	28%	13%	14%	5%	13%	20%	5%	2%	0%
	MWH	Visit 4	29%	2%	22%	2%	10%	11%	0%	3%	6%
	CYK	Visit 1	11%	4%	28%	2%	15%	14%	7%	7%	0%
	TCW	Visit 1	15%	0%	25%	5%	12%	9%	13%	5%	6%
	LPM	Visit 1	30%	5%	10%	2%	8%	10%	4%	10%	3%
27	**CYK**	Visit 4	34%	2%	15%	4%	15%	9%	10%	5%	5%
	TCW	Visit 4	17%	0%	21%	9%	19%	6%	8%	11%	3%
	LPM	Visit 4	25%	4%	13%	2%	10%	10%	12%	12%	2%

Longitudinal study

Age (months)	Name	Visit	T55	T5	T33	T3	T35	T21	T23	T22	T2
12	**YPK**	Visit 1	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Visit 2	4%	0%	0%	0%	0%	0%	0%	0%	0%
		Visit 3	5%	0%	0%	0%	0%	0%	0%	0%	0%
		Visit 4	16%	0%	0%	0%	12%	0%	0%	0%	0%
15	**YMY**	Visit 1	5%	0%	3%	0%	3%	0%	0%	0%	0%
		Visit 2	28%	6%	0%	0%	0%	0%	0%	0%	0%
		Visit 3	21%	0%	27%	18%	3%	0%	0%	0%	0%
		Visit 4	26%	0%	15%	0%	18%	1%	0%	0%	0%
18	**TCJ**	Visit 1	25%	2%	27%	2%	9%	9%	0%	0%	0%
		Visit 2	48%	3%	24%	6%	9%	5%	0%	0%	0%
		Visit 3	30%	0%	24%	3%	14%	0%	0%	0%	3%
		Visit 4	13%	8%	25%	11%	19%	0%	0%	0%	5%
21	**TKC**	Visit 1	22%	2%	17%	5%	14%	13%	11%	1%	0%
		Visit 2	22%	1%	13%	1%	6%	12%	3%	1%	1%
		Visit 3	24%	5%	18%	1%	10%	19%	8%	0%	3%
		Visit 4	28%	13%	14%	5%	13%	20%	5%	2%	0%
25	**LPM**	Visit 1	30%	5%	2%	8%	10%	10%	4%	10%	3%
		Visit 2	21%	2%	2%	9%	21%	12%	6%	11%	0%
		Visit 3	23%	4%	2%	13%	16%	10%	4%	11%	3%
		Visit 4	25%	4%	13%	2%	10%	10%	12%	12%	2%